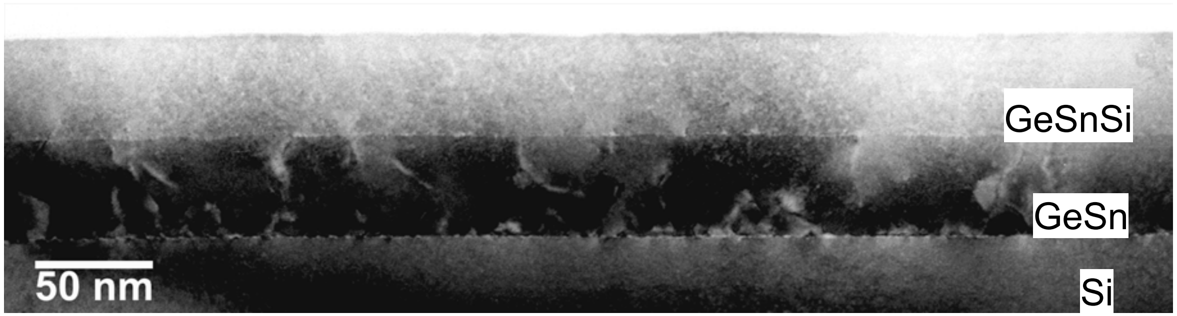
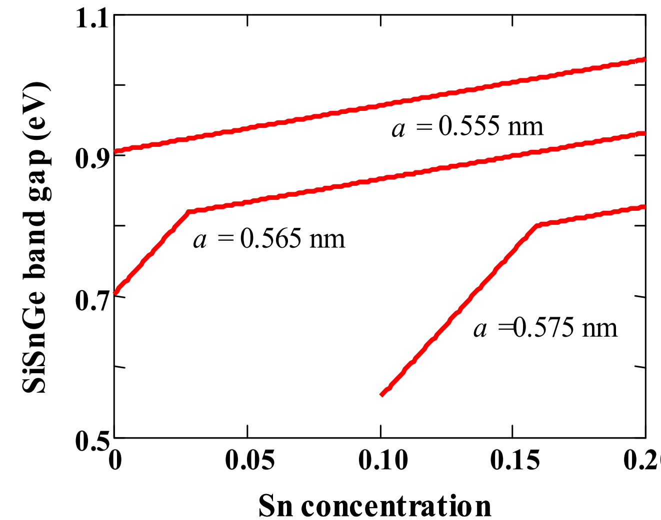
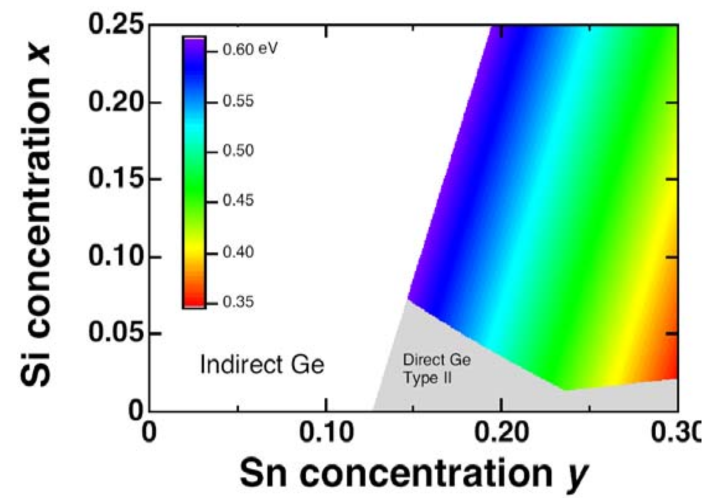
Synthesis of Multi-Wavelength $Ge_{1-x-y}Si_xSn_y$ Semiconductors and Related Photonic Device Structures

John Kouvetakis, Arizona State University, DMR-0221993





Si and Ge have not been considered desirable materials for optical applications because their electronic band structures and lattice constants make it difficult to fabricate certain key optical components. To overcome these limitations we are developing a new class of Si-Ge-Sn materials directly on Si. These materials will be used to fabricate photonic devices, including modulators and photodetectors, based entirely on the group IV Ge, Sn-Ge and Si-Ge-Sn systems. As shown in the electron micrograph (above) we have demonstrate for the first time the creation of device-quality, defect-free $Ge_{1-x-y}Si_xSn_y$ heterostructures on $Ge_{1-z}Sn_z$/Si(100) substrates. The graph (top right) illustrates that a wide range of $Ge_{1-x-y}Si_xSn_y$ band gaps can be covered with a single value of the lattice constant. Therefore, $Ge_{1-x-y}Si_xSn_y$ alloys which are fully integrated with Si could represent a viable alternative to other lattice matched IR systems, such as $Hg_xCd_{1-x}Te$ (MCT). Alloys of $Ge_{1-x-y}Si_xSn_y$ can serve as buffer layers to grow strained Ge films with direct tunable band gaps. Bottom graph shows the predicted band gaps of Ge/ $Ge_{1-x-y}Si_xSn_y$ (colored scale) as a function of Si and Sn content of the buffer layer. The Ge gaps (colored region) are in the IR, and light emission from this material should be strong due to the spatial confinement of electrons and holes on the same strained Ge layers (type I).



Synthesis of Multi-Wavelength $Ge_{1-x-y}Si_x Sn_y$ Optical Semiconductors and Related Device Structures

John Kouvetakis, Arizona State University, DMR-0221993

Broader Impact

Human Resourses:

Seven graduate students in chemistry and engineering [*Cole Ritter, Levi Torrison, Candi Cook, R. Trivedi, R. Rouka, Tito Garza and Lily An*] and one undergraduate [Andrew Nowak *a National Merit Scholar*] were funded in part by the grant during the academic year 2003-2004. Torrison received his Ph.D. in December 2003 and he is presently teaching. Very recently degrees in Science and Engineering of Materials were awarded to R. Rouka (Ph.D.) and Candi Cook (M.S.). Trivedi will defend his thesis in November 2004.

Technological Impact and Industrial Outreach:

Five patents (US/International) have been filed since 12/2003. Several US Companies (Matheson-Nipon, Applied Materials, Voltaix et al.) are currently engaged in discussions with ASU to license intellectual property derived from work supported by the grant.